



File Code: 3420

Date: May 2, 2007

Route To: (2300), (2400), (2600)

Subject: An Assessment of Deicing Salt Damaged Trees Along Highways 87 and 260, Mogollon RD, Coconino NF

To: District Ranger, Mogollon Ranger District, Coconino National Forest

At the request of Jill Oertly, Wildlife Biologist, I visited the District to view salt damaged trees along State Highways 87 and 260. We were joined by Henry Brill, Rose Harley, and Mark Swift of the Mogollon Ranger District, along with Justine DeLangue, Volunteer, Rocky Mountain Research Station. We focused on examining trees that were recognized as hazard trees by the Arizona Department of Transportation (ADOT) and marked for removal. A tree is defined as a hazard tree when it has both a structural defect that could cause the tree to fail, and a target to strike when it fails. Along a roadway, a tree is hazardous when it has a defect and could land on the road when it fails. Injuries could occur by directly hitting a vehicle on the road or by causing a driver of a car to swerve in order to miss a tree that has landed in his or her path. The purpose of this letter is to describe the effects of deicing salts on roadside trees, the process of decay and failure of killed trees, and mitigation measures to reduce hazard trees along roadways.

Current Condition

Earlier this year, the Arizona Department of Transportation (ADOT) marked over 500 dead trees along Highways 87 and 260. The majority of these trees died due to exposure to deicing salts and, in many cases, subsequent attack by bark beetles (Figure 1). There are several trees near the junction of Highways 87 and 260 that died from fire injury. Most trees had died somewhere between the past few months and last 3 years.

Although some snow melting mixtures were used in the past, ADOT started using the deicing agent, Ice Slicer®, and an anti-icing agent, liquid magnesium chloride, in 2001 to reduce vehicle accidents during winter storms. Although ADOT first began applying these salt mixtures in the Flagstaff area, application was extended to other areas including Highways 87 and 260 on the Mogollon RD within the past few years. Chloride damage to roadside vegetation began appearing almost immediately even though Ice Slicer®, a natural mined compound from Utah, is promoted as being safer for the environment than straight sodium chloride. Additionally, although ponderosa pines are considered moderately susceptible to

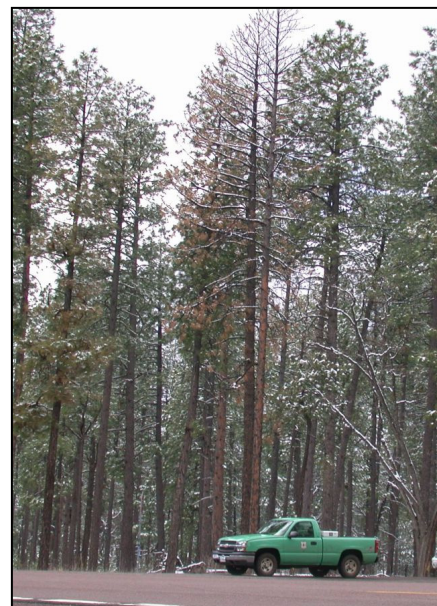


**Figure 1 Salt damaged trees
along Highway 87.**



salt damage mortality has been common throughout the State. Ice Slicer® is a mixture of sodium chloride along with other salts including magnesium chloride and calcium chloride.

The level of salt damage varies along the roughly 15 miles surveyed, with groups of trees on either-or-both sides of the roadway exhibiting symptoms that include: Tip burn (yellow to brown needle tips with green bases on one-year needles); differential discoloration on the side of the crown closest to the roadway; entire crown of trees with tip burn; branch dieback; topkill; and mortality. When there is a bank to the roadway, trees on the downhill side of the slope exhibit symptoms since runoff carries the salts downhill.

Although nearly all trees marked for removal are dead, there were a couple of salt damaged trees with green needle bases and a few large living trees with advanced decay leaning over the road that were selected for extraction. Since these trees are still alive, slash should be taken away from the roadway so that ips bark beetles do not attack the newly created slash and emerge to infest living trees. Ips does not breed in slash from dead trees.

Salt Damage

The effects of salt on trees adjacent to roads have been documented for decadesⁱ. Salts applied as a dust palliative (CaCl and MgCl) or for deicing (NaCl, MgCl and CaCl) cause leaf scorch, twig dieback, and deathⁱⁱ. Damage can be caused either by salt spray thrown on aerial parts of trees from fast moving traffic or excessive soil salinityⁱⁱⁱ, although symptoms differ slightly. In conifers, salt spray causes tip burn of one-year needles. In the spring the tips turn yellow and eventually brown, while the bases of affected needles stay green (Figure 2). There is a clear demarcation between the basal green and terminal brown tissue. The bases turn brown in the fall and the needles drop early. Excessive soil salinity also causes tip burn, but the entire tree is affected rather than just parts exposed to salt spray. Another distinguishing symptom of saline soils is lack of growth as buds fail to open.



Figure 2 Green bases on salt damage needles.

In a study conducted in 2005 along Highway 260 near Forest Lakes^{iv}, Arizona, foliage samples collected from symptomatic trees yielded significantly higher concentration of sodium and chloride (P values <0.001) than did samples from asymptomatic trees. Symptomatic trees averaged 0.5% sodium and 0.9% chloride concentrations, over twelve and three times greater, respectively, than the average level of sodium (0.04%) and chloride (0.3%) in asymptomatic samples. Levels of magnesium and calcium were not significantly different between symptomatic and asymptomatic samples. Discolored trees were significantly closer to the road (P values <0.001) than green trees, with affected trees averaging 24 feet compared to unaffected trees which averaged 54 feet. Most affected trees sampled were within 30 feet of the edge of the road.

Although magnesium chloride has been reported by some researchers to be less toxic to plants than sodium chloride, in excessive concentrations it can also cause needle discoloration, dieback

and death. In 2000, elevated levels of both magnesium and chloride ions were found in symptomatic ponderosa pine along an unpaved roadway outside of Pinetop, Arizona, sprayed for dust abatement^v.

Although there are differences in salt tolerance between tree species, no species is immune to damage. Even the most tolerant plants die if they are exposed to salt in sufficiently high concentrations. Ponderosa pine is considered tolerant to salt spray but moderately susceptible to damage by excessive salt in soils^{vi}.

Deterioration of Dead Trees

Once a tree is dead, decay processes degrade the structural integrity of trees fairly quickly. The primary agents causing deterioration of recently killed trees are fungi and insects, with a succession of types and species changing from year to year until no sound wood remains. The process starts just under the bark and progresses rather uniformly toward the pith. In general, most activity during the first year is from blue stain and incipient decay and results in very little structural degradation^{vii}. By the end of the second year, degradation of the sapwood can be complete, but depends largely upon the thickness of sapwood, tree species, and tree size. By the end of the third year, practically no sapwood is sound, especially in smaller trees and the tops of larger trees. The outer heartwood also has appreciable deterioration in some trees.

The natural fall rates of recently killed trees are variable and depend on tree size, species, environment, and weather (especially strong wind events)^{viii}. Although a few dead trees can stand for decades, most fail within the first 3 years of death. Since dead trees need to be removed before they may impact the safety of a sawyer, it is recommended to remove dead trees within one year of death.

Summary

The salt induced mortality found along Highways 87 indicates too much salt is deposited on the plants and in the soil for them to survive. Although rainfall leaches salts out of the soil during the summer months, seasonal application of salts will result in continued damage and mortality and development of hazardous trees. Trees within approximately 30 feet of the edge of the roadway are being impacted by deicing and anti-icing compounds. An effective way to reduce mortality and subsequent hazard tree maintenance along roadways where deicing compounds are applied requires the removal of trees within the first 30 feet of the edge of the road. Fewer trees will be damaged from salts and fewer trees will die. An added benefit to tree removal is that it allows more sunlight on the road, decreasing the need for deicing agents. Although the removal of these target trees is expected to reduce yearly hazard tree maintenance, we are unsure of impacts to vegetation beyond 30 feet as deicing salts continue to accumulate in soils adjacent to roadways.

Since the death of trees has occurred over a period of 3-4 years, recently killed trees are interspersed with many trees whose failure is imminent. The proposed plan for the expeditious removal of all dead trees along the roadway will reduce the risk of injury to people and their property on the highways.

If a tree removal project is planned, our office recommends that slash be generated between late summer and the end of December, if possible, in order to lessen the buildup of ips bark beetles.

Slash piles should be placed in stand openings as much as possible and the largest diameter slash put on the outside of the pile to promote quick drying. Teepee style slash piles with branches and small-diameter slash in the middle and the larger diameter material on the outside.

If you have any questions regarding this evaluation, please let us know. I can be reached at (928) 556-2075 or mfairweather@fs.fed.us

/s/ Mary Lou Fairweather
MARY LOU FAIRWEATHER
Forest Pathologist, Forest Health, Arizona
Zone

cc: John Anhold
Debra Allen-Reid

ⁱ Strong, F.C. 1944. A study of calcium chloride injury to roadside trees. Michigan Quarterly Bulletin 27: 209-224.

ⁱⁱ French, D.W. 1959. Boulevard trees are damaged by salt applied to streets. Minnesota Farm and Home Scientist 16: 9, 22, 23.

ⁱⁱⁱ Dobson, M.C. 1991. De-icing salt damage to trees and shrubs. Department of the Environment Arboriculture Contract. Forestry Commission Bulletin 101, 64p.

^{iv} Fairweather M.L. 2005. Evaluation of salt toxicity of ponderosa pine along State Highway 260, Black Mesa RD, Apache-Sitgreaves NF. USDA Forest Service, Southwestern Region, Forest Health, Arizona Zone Office, 3 p. Flagstaff AZ.

^v Fairweather, M.L. 2000. Evaluation of tree discoloration and damage on Forest Road 182, Lakeside Ranger District (RD), Apache-Sitgreaves National Forest. USDA Forest Service, Southwestern Region, Forest Health, Arizona Zone Office, 5 p. Flagstaff AZ.

^{vi} Scharpf, R. and M. Srago. 1974. Conifer damage and death associated with the use of deicing salt in the Lake Tahoe basin of California and Nevada. USDA Forest Service California Region Forest Pest Control. Technical Report. 17 p.

^{vii} Kimmey, J.W. 1955. Rate of deterioration of fire-killed timber in California. USDA Forest Service, California Forest and Range Experiment Station, Circular No. 962. 22 pp.

^{viii} Schmid, J.M., S.A. Mata, W.F. McCambridge. 1985. Natural falling of beetle-killed ponderosa pine. Res. Note RM-454. Fort Collins, CO: Rocky Mountain Research Station, Forest Service, U.S. Department of Agriculture; 3 p.